

INTERIM
REPORT ON THE FIELD
OPERATION OF A RESIDENTIAL
SPACE HEATING AND COOLING SYSTEM

A Housing Energy Management Program Report



Energy
Ontario

INTERIM
REPORT ON THE FIELD
OPERATION OF A RESIDENTIAL
SPACE HEATING AND COOLING SYSTEM

Prepared for
Ontario Ministry of Municipal Affairs and Housing
Technical Services Division
Research and Development Section

by

THE CONSUMERS' GAS COMPANY LTD.

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1.0 INTRODUCTION

Discussions between the Ministry of Municipal Affairs and Housing and The Consumers' Gas Company Ltd. held during the early part of 1981 emphasized areas of mutual interest in the field evaluation of high efficiency energy conserving equipment to demonstrate how new equipment would operate in a real life situation.

As a result of these discussions the Ministry of Municipal Affairs and Housing and The Consumers' Gas Company Ltd. decided to field test a new style of residential space conditioning system which had been designed, developed and manufactured in Canada. This system would be evaluated against existing conventional equipment to ascertain the operating cost savings which could be attributed to the new device when it replaced a typical existing conventional furnace.

Two such systems were evaluated, in the as manufacturer received, as contractor installed condition, during the 1981-82 heating season, with funding being shared on an equal 50-50 basis between the Ministry of Energy, administered by the Ministry of Municipal Affairs & Housing and The Consumers' Gas Company Ltd.

An installation report entitled "Kool Fire Home Comfort Control System Field Trials" was published in the Fall of 1981. This interim report on the field operation of the residential space heating and cooling system contains data collected during part of the 1981-82 heating season, an analysis of that data and the computed annual operating costs. The unit was tested in the heating mode only and no cooling data was collected or analyzed.

1.1 OBJECTIVE OF TEST

The objective of the test was to ascertain the operating cost of this space heating device and compare that cost to the traditional older model warm air heating system costs. The comparison would allow the homeowner to determine how this device compares to other established new models of heating systems for which published operating data might be available.

1.2 DESCRIPTION OF THE SPACE CONDITIONING SYSTEM UNDER TEST

The appliance tested is a residential space heating and cooling device, invented, developed and manufactured in Niagara Falls, Canada and supplied through an Oakville distributor. The unit is CGA approved.

Basically the appliance is a split system heat pump with the conventional supplemental heating being replaced by a natural gas burner which fires directly through the outdoor heat transfer coil. The burner is housed in the external enclosure. The composite unit provides the full winter heating requirements of the dwelling without the need for a separate supplementary heating system and additionally it provides air conditioning in the summer. The efficiency of heat transfer from the gas burner into the outdoor coil is such that this supplemental heating is claimed to be a highly efficient condensing furnace. The

manufacturer claims that in the heating mode, the system has a steady state thermal efficiency of 98%.

Other claimed advantages of the system are:

1. The gas furnace is located in the outdoor unit, which eliminates the need for a chimney or flue in the residence.
2. The gas supply piping can be installed outdoors.
3. The design of the unit is such that it eliminates the defrost cycle which implies that there will be an energy improvement over the conventional type of heat pump.

A potential energy disadvantage could be that any residual heat is lost to the outside atmosphere, whereas in a conventional furnace, a portion of the residual heat dissipates into the residence.

The operation of the unit is not particularly complex. In the cooling mode the device functions in a manner similar to a conventional central air conditioner with the indoor coil extracting heat from the residence and pumping it into the external atmosphere. In the heating mode the cycle is reversed by the action of a simple reversing valve, actuated by the home thermostat, and the appliance extracts heat from the outdoor atmosphere and pumps the energy gathered into the indoor fan coil unit, for distribution throughout the home.

As supplied by the manufacturer, when the outdoor temperature is around 10°C the unit switches automatically to the condensing gas furnace mode to supply all of the heat required to satisfy the residential requirements. In this mode of operation, the gas burner fires directly into the internal section of the outdoor air A-coil, supplying the energy of combustion to the heat transfer fluid in the device. The heated fluid is then passed through the compressor, which still operates to supply some further additional heat and the fluid is then pumped into the indoor fan coil unit, where it gives up its heat for distribution throughout the residence.

Technical information on the unit is shown on pages 5 and 6 and a schematic of the unit is shown in Figure I Page 7.

TECHNICAL INFORMATION

Operating Modes

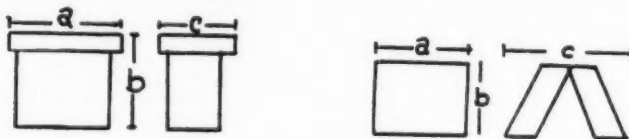
- Heat Pump
- Air Conditioner
- Condensing Gas Furnace
- No defrosting cycles are required

The most efficient operating mode is automatically selected.

Mechanical Specifications

Dimensions of Units

	a	b	c
Exterior Unit	135	109	66
Interior Unit	61	61	56



All sizes above shown in centimeters

Weight of Units

Exterior Unit - 136 kg.
Interior Unit - 41 kg.

Maximum Allowable Distance Between Units

18.28 m

Unit Sections Connected By

1 Electrical line 1.90 cm O.D.
and 1 (one) 1.59 cm O.D. pipe
and 1 (one) .95 cm O.D. pipe

Minimum Size of Opening Required for Connecting Pipes

10.16 cm O.D.

Size of Chimney Required

Nil

Volume of Inside Combustion Air Consumed

Nil

Weather Protection Required for Exterior Section

Snow - Nil
Rain - Nil

Range of Outside Temperatures for Efficient Operation

-40°C to 46°C

Energy Requirements - 230 - 115 VAC for operating compressor and fan motors. (Does not require 200 Amp. service)

- Natural Gas or
- Propane Gas for heating

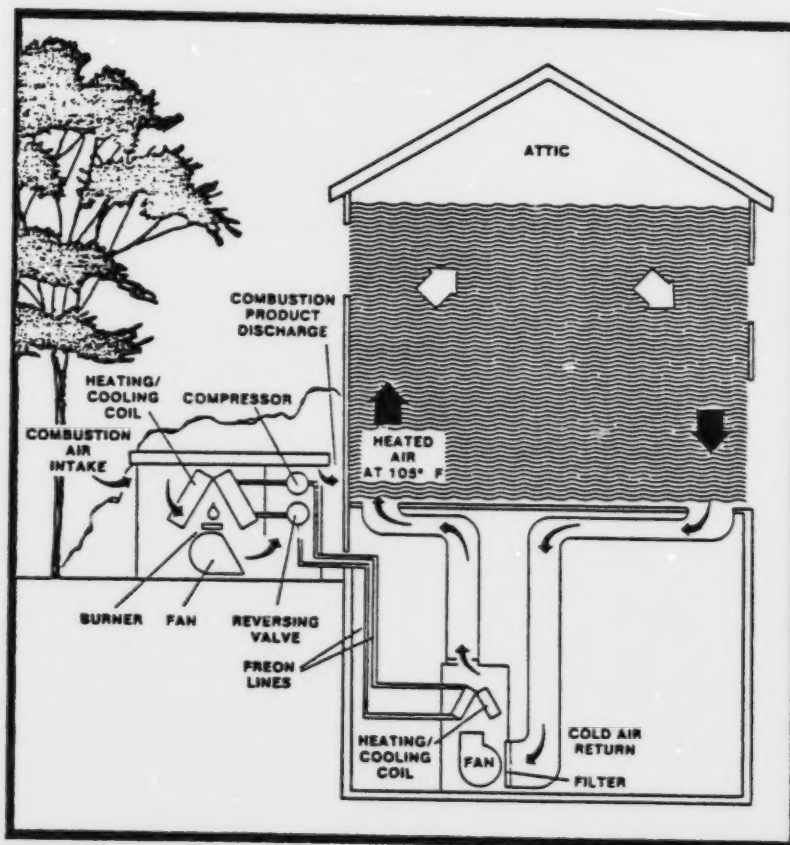
Installation

- The heating and cooling compressor, heating and cooling coil, combustion unit and controls are installed in a galvanized and painted steel container outside the home.
- A heating and cooling coil, filter, circulation fan and thermostat are installed inside the home using:
 - a. some of your existing equipment
 - b. a new enclosure in your home
- A 10 cm square opening is required for the connecting piping between the exterior and interior unit
- existing duct work is used

Maintenance

- all parts and components are readily available from off the shelf supplies and are designed for quick and easy maintenance by service men.

FIGURE 1



SCHEMATIC OF SYSTEM

INSTALLATION

2.0 INSTALLATIONS

Two models of the device, purchased for the field tests, were installed in two different sized and styled homes, one in Bowmanville, Ontario, and the other in Willowdale, Ontario. The systems were installed in the manufacturer "as received" condition and tested as setup by the approved installing contractor.

Both units were installed on concrete pads, a recommended safety procedure from the manufacturer, to prevent the possibility of frost heave distorting the rigid gas supply line to the unit. This distortion would weaken joints and could result in leakage from the gas piping. Flexible connectors, similar to those used on a gas range, have been approved recently for use on outdoor appliances and the introduction of these items may eliminate the need for the concrete pad. The manufacturer, however, now recommends that the outdoor unit be located on a base of well laid patio stones to allow condensate drainage. An accumulation of the condensate below the unit could initiate corrosion of the cabinet bottom over the long term.

2.1 MODIFICATION OF EXISTING HEATING SYSTEM

Modification to the existing flueing system was recommended by the supplier. "Blast Gate" sliding plate type dampers were fitted into the existing fossil furnace flue systems in order that the heat loss, due to stack effect, could be eliminated during the period when the novel device was being operated. To

ensure that the conventional fossil fueled furnace could not be operated inadvertently, when the "Blast Gate" damper was in the closed position, an electrical interrupter or isolating switch was installed such that the furnace could not be operated without this switch being activated by the owner physically opening the flue damper. This system has operated exceptionally well to date.

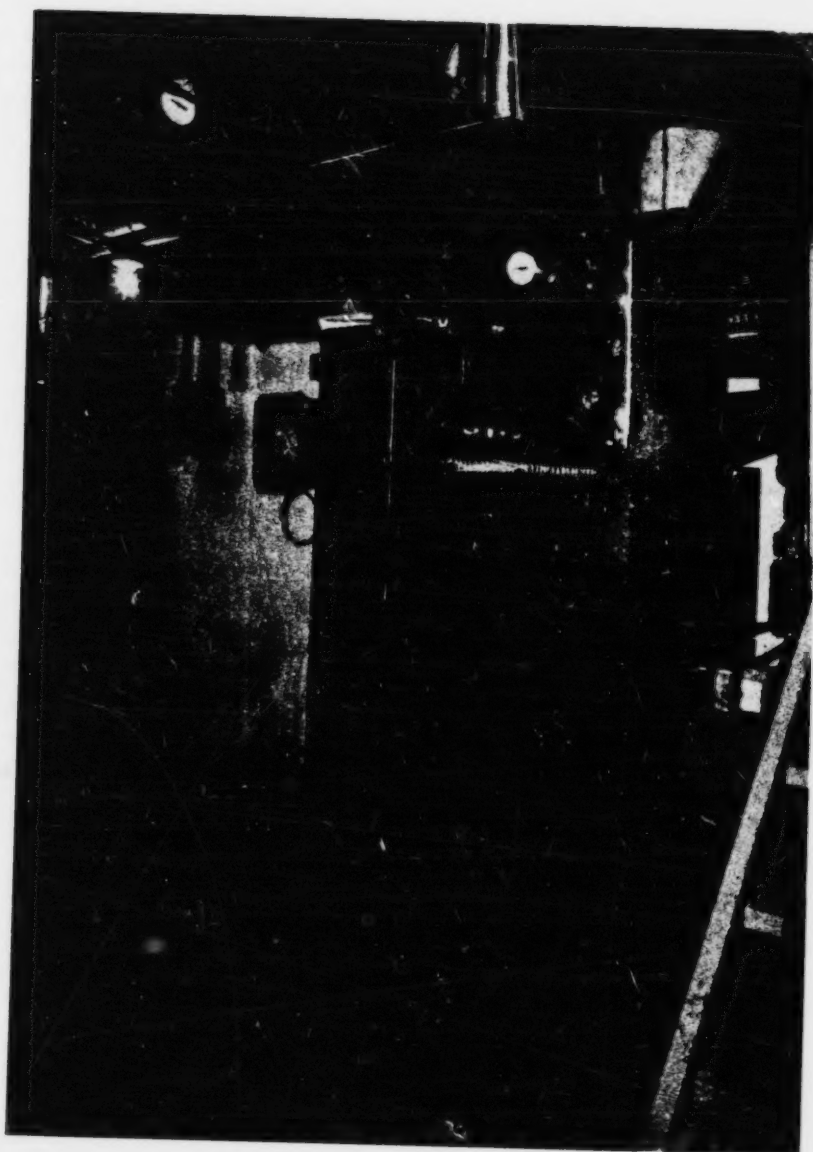
Both sites were instrumented in a similar manner with outside temperature recorders, inside temperature indicators, degree day meters and individual unit energy consumption meters. Timers to record the individual cumulative "on times" of various electric motors were also installed.

In addition to the recording and indicating instrumentation Ontario Hydro Research Division provided an automatic recording system which transferred energy consumptions from each appliance onto a magnetic tape. The pulses were transferred to the tape recorder every fifteen minutes.

The site instrumentation and installation is shown in Figures 2, 3, and 4 on pages 10, 11 and 12.

The space heating and cooling devices were tested on a manually operated flip flop basis with the existing traditional and conventional furnaces. At one site the change over was conducted daily whereas at the other site the change over was conducted weekly.

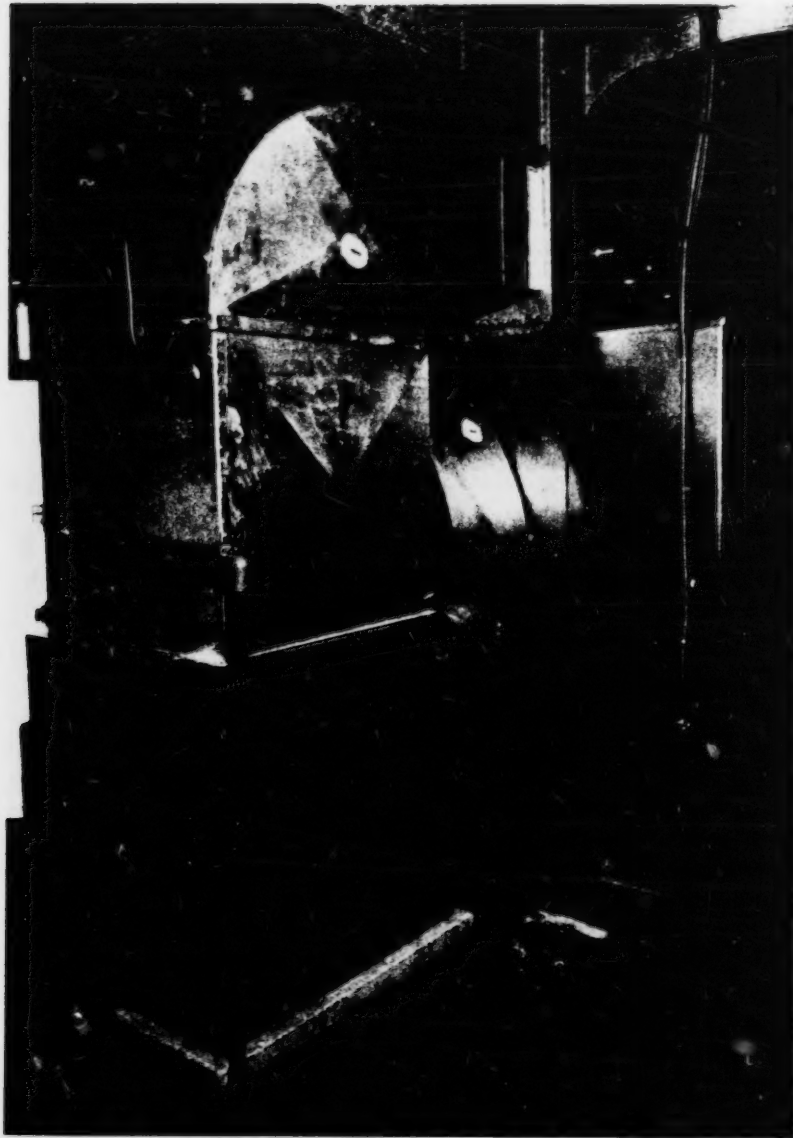
FIGURE 2



INSTRUMENTATION AT BOWMANVILLE SITE

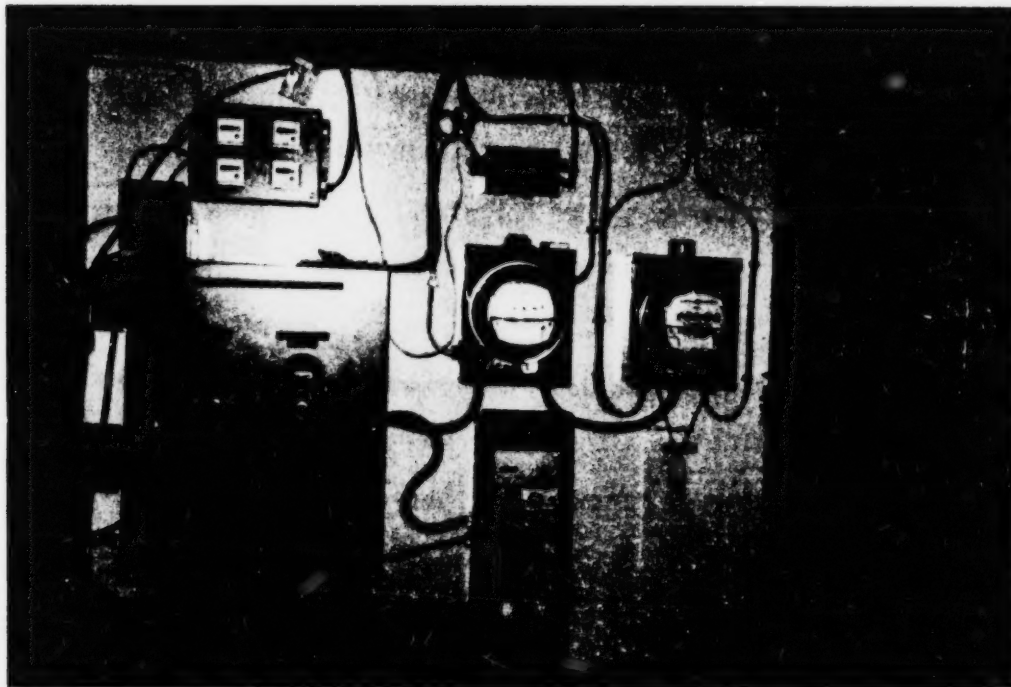
FIGURE 3

DUCT
THERMOMETERS



WILLOWDALE SITE

FIGURE 4



ONTARIO HYDRO RESEARCH RECORDING INSTRUMENTATION

3.0 SITE READINGS AND RESULTS

3.1 BOWMANVILLE

The test site at Bowmanville is a detached frame construction brick veneer and aluminum siding two storey residence of approximately 152 square meters living area. The house is of tight construction with R28 fibreglass insulation in the attic and R12 fiberglass insulation in the basement walls. A view of this site is shown in Figure 5 on page 14.

The heating requirements for this house was calculated at 19.5 kW, using the HRAI manual and a suitable model of the new appliance was selected. The existing equipment is a conventional eight year old gas fueled warm air furnace, with an input rating of 35 kW. This furnace is approximately 44% oversized, as is to be expected in an installation of this age.

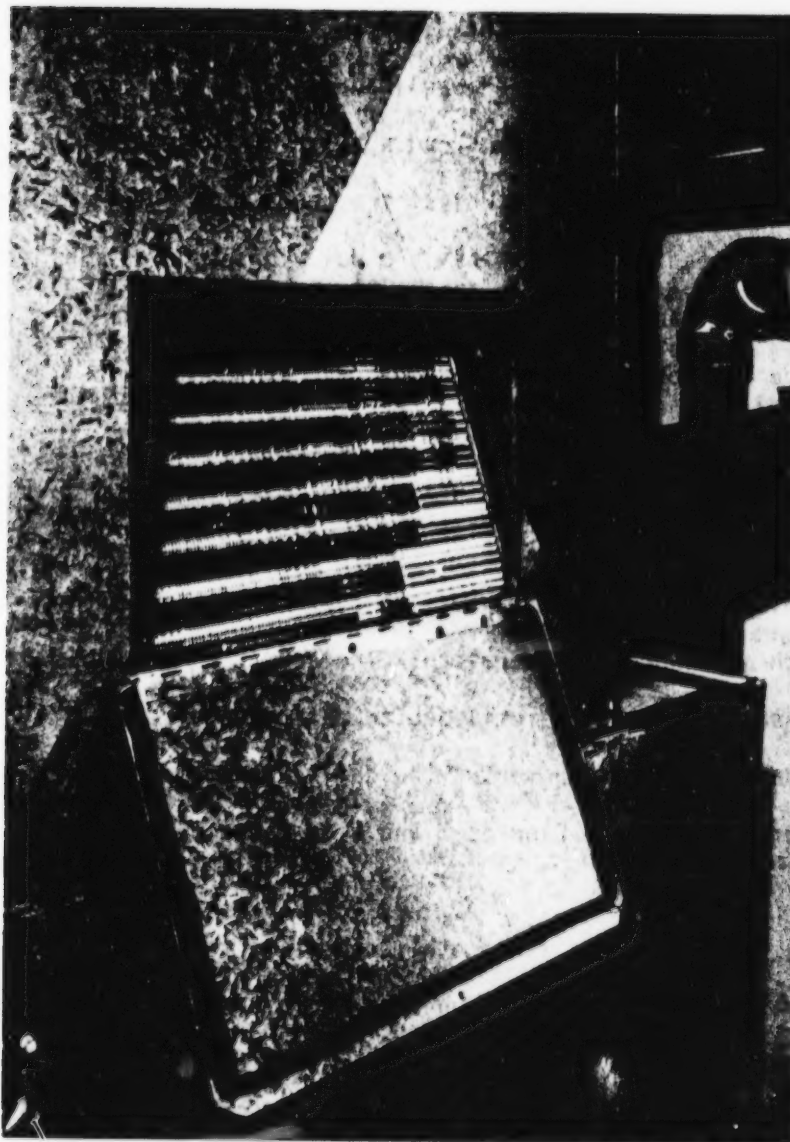
At this location, the indoor coil was installed in the warm air plenum above the existing conventional gas furnace and the existing gas furnace blower was used to distribute the tempered air from either device throughout the residence. As such, no isolating dampers are required at this site. The blower motor power was increased from 118 watts to 249 watts to provide the greater air flow requirement for the heat pump/condensing gas system. The indoor coil of the system is located in the existing furnace plenum as shown in Figure 6 on page 15.

FIGURE 5



BOWMANVILLE SITE - AN EIGHT YEAR OLD HOME

FIGURE 6



COIL INSTALLED IN EXISTING WARM AIR FURNACE PLENUM
AT THE BOWMANVILLE SITE

The Bowmanville site was commissioned during early January 1982, and initially both readings and change overs were conducted on a weekly basis, however, it became apparent that the frequency of change over and reading taking was inadequate. During the period of mid-March to mid-April both readings and change overs were conducted on a daily basis. Whilst the rough data sheets recorded the readings on a weekly and daily basis, a simplified set of summary tables and charts showing monthly consumptions and costs have been produced for brevity and clarity.

Table I, page 18, shows the actual monthly electric and gas consumptions for both units at Bowmanville, over the period during which readings were taken, and over the period during which each appliance was operating. The actual weekly and later daily consumption data was utilized to determine a regression line of daily consumption versus the daily average outside temperature is shown in Figures 7 and 8 on pages 19 and 20.

Table II, page 21, shows the monthly operating costs for each unit over the period during which each has been operating, based on the readings taken throughout the duration of the test.

From the data analyzed, it appears that the new system is fractionally more expensive to operate than the conventional furnace. However, the potential savings attributable to the novel device would be prominent during the Fall and Spring periods when the unit operates only as a heat pump. This trend can be noticed from Table III, page 22, during the Spring months

of March and April. With the settings provided by the manufacturer the unit ran infrequently as a heat pump. Over the complete season, the computed operating costs show that the new hybrid system is slightly more expensive to operate than the conventional gas furnace for the 1981-82 heating season. See Table III on page 22.

In order to arrive at an average annual operating cost, the actual data obtained from the site was applied to Canadian climate normals gathered over the past 30 years. The computation shows that the average annual operating cost for the new device would be \$398.59 and for the conventional gas furnace the operating cost would be \$427.74/year, a saving of approximately \$29/year or 7% savings over the gas furnace. The analysis is shown in Table IV on page 23.

A tail end or composite gas rate of $21\text{¢}/\text{m}^3$ and an electric rate of $3.55\text{¢}/\text{kWh}$ has been used throughout in all cost calculation comparisons.

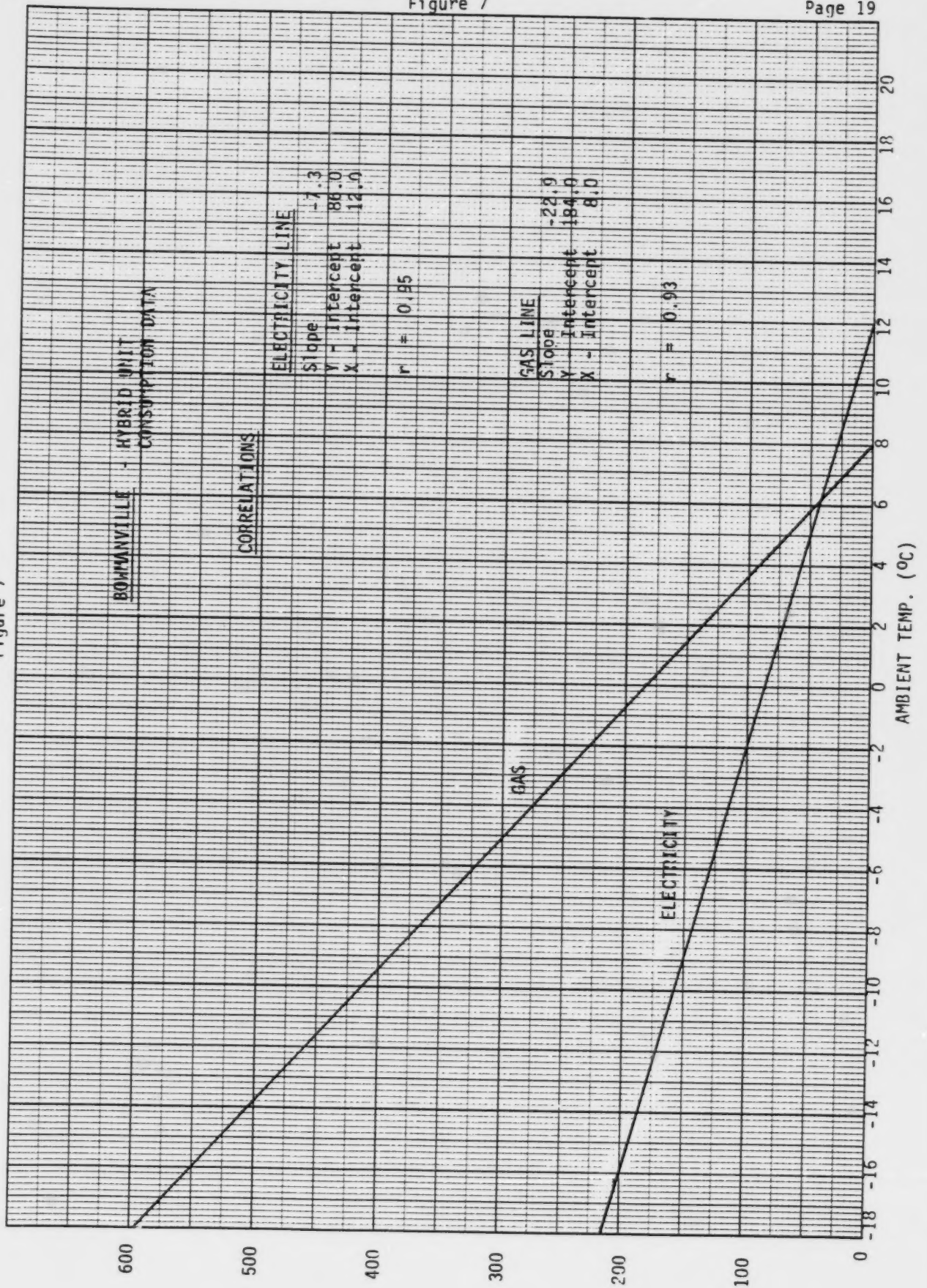
TABLE I

SUMMARY OF ACTUAL FUEL CONSUMPTION OVER PERIOD DURING WHICH EACH APPLIANCE OPERATED
BOWMANVILLE SITE 1981-82

MONTH	NEW SYSTEM			CONVENTIONAL UNIT		
	Electricity Consumption (kWh)	Gas Consumption (m ³)	No. of Days Operating	Electricity Consumption (kWh)	Gas Consumption (m ³)	No. of Days Operating
January	702	176	17	106	218	14
February	431	102	14	108	161	14
March	332	71	15	106	127	16
April	242	34	16	96	76	14
Totals	1707	383	62	416	582	58

*Actual fuel consumption data was obtained primarily on a weekly basis. This data was utilized to draw the graph from which the regression lines were computed.

Figure 7



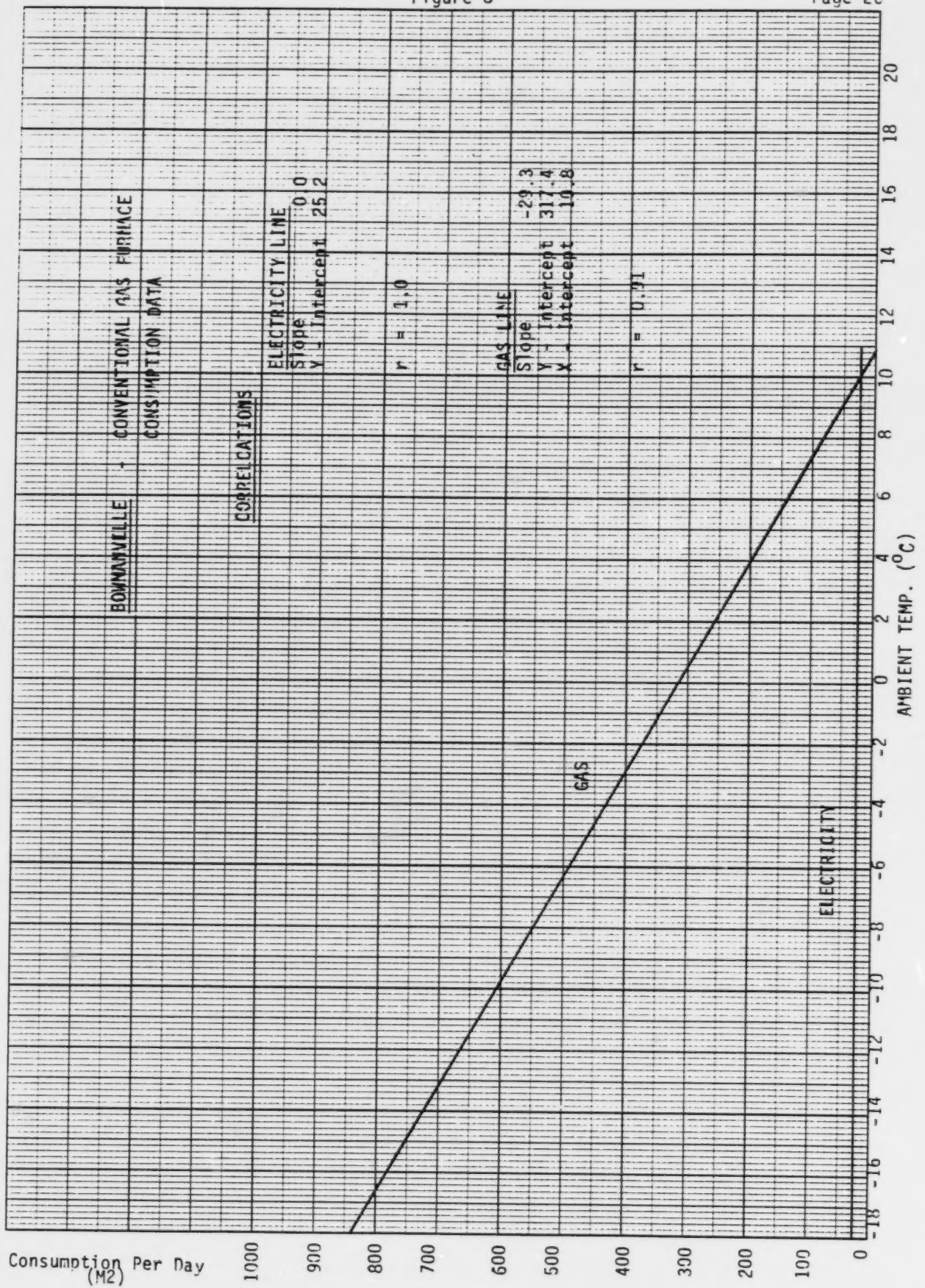


TABLE II
 SUMMARY OF OPERATING COSTS OVER PERIOD DURING THE MONTH WHICH EACH APPLIANCE OPERATED
 BOWMANVILLE SITE 1981-82

MONTH	NEW SYSTEM			CONVENTIONAL UNIT		
	Elec. (\$)	Gas (\$)	Sub Total (\$)	Elec (\$)	Gas (\$)	Sub Total (\$)
January	24.92	36.96	61.88	3.76	45.78	49.54
February	15.30	21.42	36.72	3.83	33.81	37.64
March	11.79	14.91	26.70	3.76	26.67	30.43
April	8.59	7.14	15.73	3.41	15.96	19.37
Total			141.03			136.98

* These costs have been computed using the energy rates indicated below:

Natural Gas 21¢/m³ Electricity 3.55¢/kwh

To obtain total monthly consumption the sub totals would be added.

TABLE III
1981-82 COMPUTED SEASONAL HEATING COSTS
BOWMANVILLE SITE

MONTH	MEAN MONTHLY TEMP. (°C)	CONSUMPTION/MONTH				COST/MONTH			
		NEW SYSTEM		CONVENTIONAL UNIT		NEW SYSTEM		CONVENTIONAL UNIT	
		Elec (kWh)	Gas (m³)	Elec (kWh)	Gas (m³)	Elec (\$)	Gas (\$)	Elec (\$)	Gas (\$)
July 81	21	0	0	0	0	0	0	0	0
August 81	20	0	0	0	0	0	0	0	0
September 81	14	0	0	0	0	0	0	0	0
October 81	7	301	20	217	94	10.69	4.20	7.70	19.74
November 81	3	534	93	210	185	18.96	19.53	7.46	38.85
December 81	-3	929	210	217	337	32.98	44.10	7.70	70.77
January 82	-10	1369	344	217	508	48.60	72.24	7.70	106.68
February 82	-7	1066	259	196	393	37.84	54.39	6.96	82.53
March 82	-2	866	191	217	313	30.74	40.11	7.70	65.73
April 82	5	413	56	210	138	14.66	11.76	7.46	28.98
May 82	15	0	0	0	0	0	0	0	0
June 82	16	0	0	0	0	0	0	0	0
Sub Totals						194.47	246.33	52.68	413.28
Totals		5478	1173	1484	1968	440.80		465.96	25.16

* This table was computed using the regression lines shown in Figures 8 and 9 and the normal monthly mean temperatures for the 1981-82 heating season.

Rates: Gas 21¢/m³ Electricity 3.55¢/kWh

TABLE IV

DATA COMPUTED TO ANNUALIZED AVERAGE 30 YEAR MONTHLY TEMPERATURE MEANS
BOWMANVILLE SITE

MONTH	30 YEAR TRUE MEAN MONTHLY TEMP. (°C)	CONSUMPTION/MONTH						COST/MONTH					
		NEW SYSTEM			CONVENTIONAL UNIT			NEW SYSTEM			CONVENTIONAL UNIT		
		Elec (kWh)	Gas (m ³)	Elec (kWh)	Elec (kWh)	Gas (m ³)	Elec (\$)	Gas (\$)	Elec (\$)	Gas (\$)	Elec (\$)	Gas (\$)	Savings (\$)
July	19.3	0	0	0	0	0	0	0	0	0	0	0	0
August	18.6	0	0	0	0	0	0	0	0	0	0	0	0
September	14.7	0	0	0	0	0	0	0	0	0	0	0	0
October	8.8	187	0	217	50	6.64	0	7.70	10.50	11.56			
November	3.2	522	89	210	180	18.53	18.69	7.46	37.80	8.04			
December	-3.6	967	222	217	352	34.33	46.62	7.70	73.92	0.67			
January	-6.7	1162	281	217	428	41.25	59.01	7.70	89.88	-2.68			
February	-5.8	998	238	196	366	35.43	49.98	6.96	76.86	-1.59			
March	-1.0	803	172	217	289	28.51	36.12	7.70	60.69	3.76			
April	5.7	370	43	210	121	13.14	9.03	7.46	25.41	10.70			
May	11.2	37	0	0	0	1.31	0	0	0	-1.31			
June	16.6	0	0	0	0	0	0	0	0	0			
Monthly Average	6.8	421	87	124	149	14.93	18.29	4.39	31.26	2.43			
Year Totals		5046	1045	1484	1786	179.14 398.59	219.45	52.68	375.06 427.74	29.15			

* This table was computed using the regression lines shown in Figures 8 and 9 and the 30 year true monthly mean temperatures.

Rates: Gas 21¢/m³

Electricity 3.55¢/kWh

3.2. WILLOWDALE

The test site at Willowdale is a detached solid brick bungalow of approximately 267 square meters living area. The house is of average air tightness and has R28 insulation in the attic and R12 in the basement walls, and no insulation in the above grade walls. The basement insulation has a 6 mils vapour barrier and 12 mm gyproc wall board covering. The windows are stormed and screened. The residence is shown in Figure 9 on page 25.

The heating load for this site was calculated at 27.7 kW using the HRAI manual and a suitable model of the new space conditioning system to be tested was selected.

The existing space heating equipment is a twenty-three year old conventional oil fired warm air furnace of 35 kW output, which is somewhat oversized but not by as much as would be expected in a home of this age.

At this site the new unit has its own individual indoor fan coil unit and the complete system is connected in parallel with the existing furnace. Manual dampers have been fitted into the supply and return duct work on each system, allowing each system to be isolated, as necessary, depending upon which system is selected to condition the residence. In addition, a manual damper was fitted into the flue of the conventional oil furnace. During the periods when the new system was running, this damper was in the closed position to prevent the transport loss through the flue. The system is shown in Figure 10 on page 26.

FIGURE 9



WILLOWDALE SITE

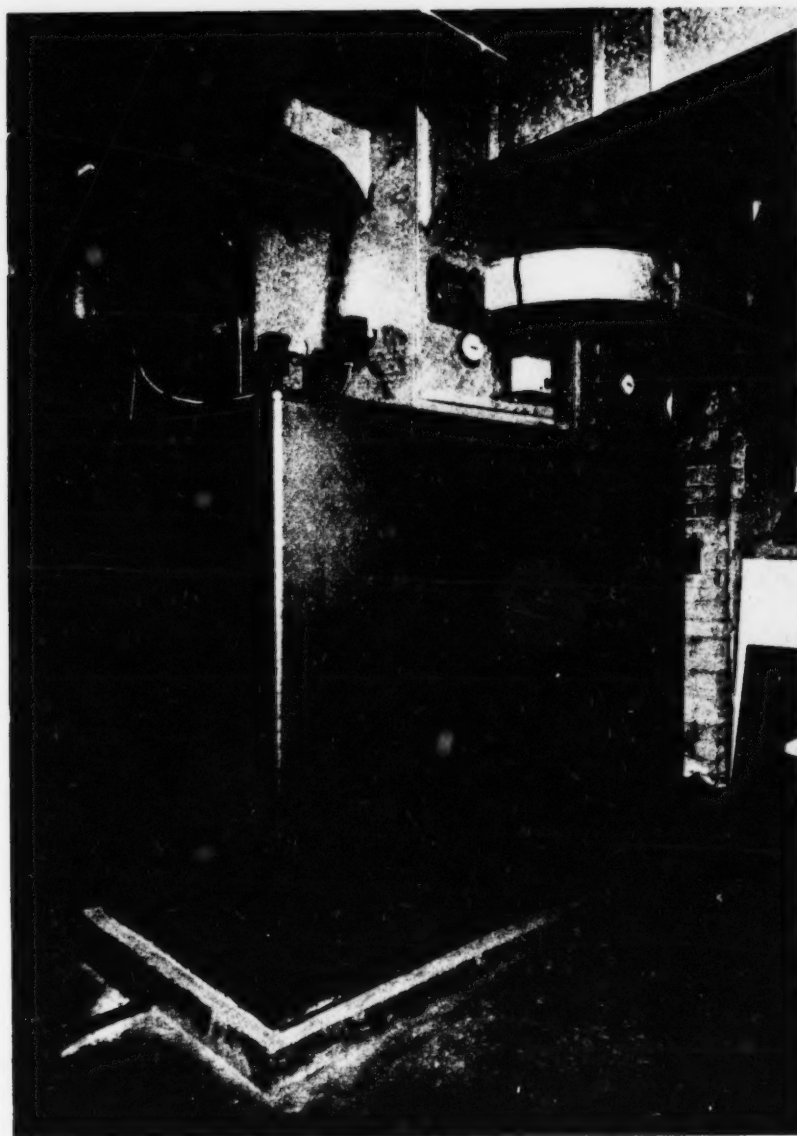
FIGURE 10

FREON
LINES
FROM
OUTDOORS

ISOLATING
DAMPERS

FAN
COIL
UNIT

CONDENSATE
DRAIN



HEATING SYSTEMS ARRANGEMENT AT THE WILLOWDALE SITE

Monitoring of the data from the Willowdale site commenced during December 1981 and continued through to April 1982. Change over and readings were conducted, where practical and possible on a daily basis at 4:30 p.m. each day. The monthly analysis of the fuel consumption readings is shown on Table V on page 29.

Figures 11 and 12 on pages 30 and 31 respectively are graphs of the daily consumptions versus the daily average outside temperature. At first glance, the graph of the new system at Willowdale (Figure 11) is more difficult to interpret as the intercept of the two lines cut the x-axis at the same point. However, whilst the lines are the best fit, their resolution is not that good because the correlation factor 'r' is 0.78 for the electric consumption and 0.73 for the gas consumption curve, compared to 0.95 and 0.93 for the electric and gas curve respectively at Bowmanville. From the amount of data obtained a super accurate line is not possible. It may be that the regression procedure is forcing a best fit linear curve whilst in reality it is possible that the curve is non linear, however it should be recognized that the collection and analysis of field data is complex because of the number of variables encountered.

As stated previously, the unit was installed in the "as received" condition and setup at the site by the authorized contractor. During the season it was noted that the unit operated as a heat pump very infrequently during the Spring months. Investigation revealed the outside temperature controller was (a) set rather

high, approximately 11°C , and that (b) the controller unit was out of calibration significantly, so much so that the appliance operated most of the season as a condensing furnace with a subsequent detrimental effect on the economics of operation.

The relevant operating costs for the period during which data was generated is shown in Table VI, page 32. These actual figures were expanded to cover the full heating season using normal temperature data and the computation indicates that the operating cost of the conventional oil furnace would have been \$1,118.73 and the new system would have been \$754.49, for an annual saving of \$364.94. This analysis is shown in Table VII on page 33.

TABLE V
SUMMARY OF ACTUAL FUEL CONSUMPTION OVER PERIOD DURING WHICH EACH APPLIANCE OPERATED
WILLOWDALE SITE 1981-82

MONTH	NEW SYSTEM			CONVENTIONAL UNIT		
	Electricity Consumption (kWh)	Gas Consumption (m ³)	No. of Days Operating	Electricity Consumption (kWh)	Oil Consumption (l)	No. of Days Operating
December	617	156	16	28	261	15
January	1058	272	19	32	273	12
February	427	99	10	41	351	18
March	599	153	16	25	216	15
April	443	105	20	9	80	10
Totals	3144	785	81	135	1181	70

*Actual fuel consumption data was obtained on a daily basis. This data was utilized to draw the graph from which the regression lines were computed.

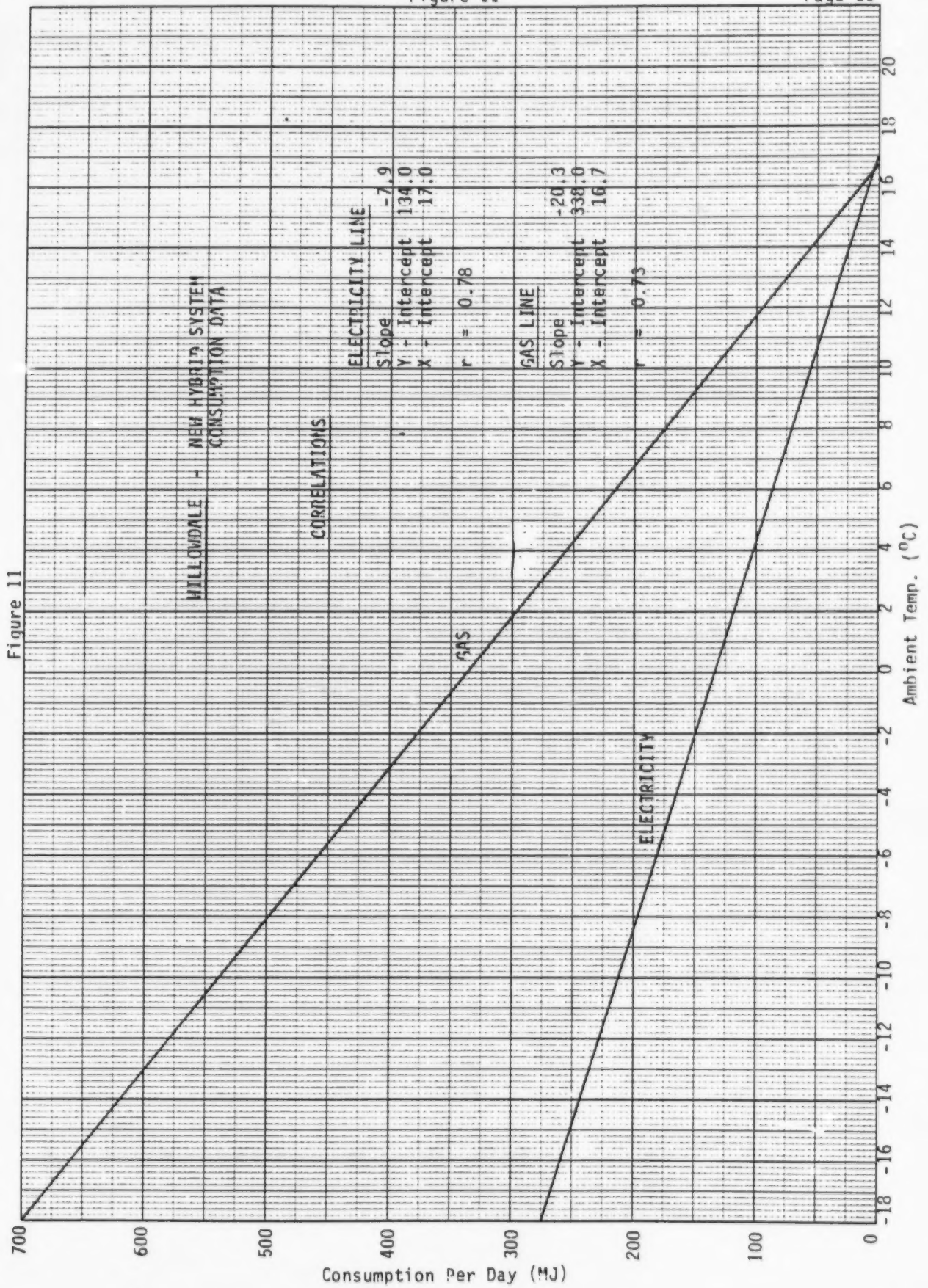


Figure 12

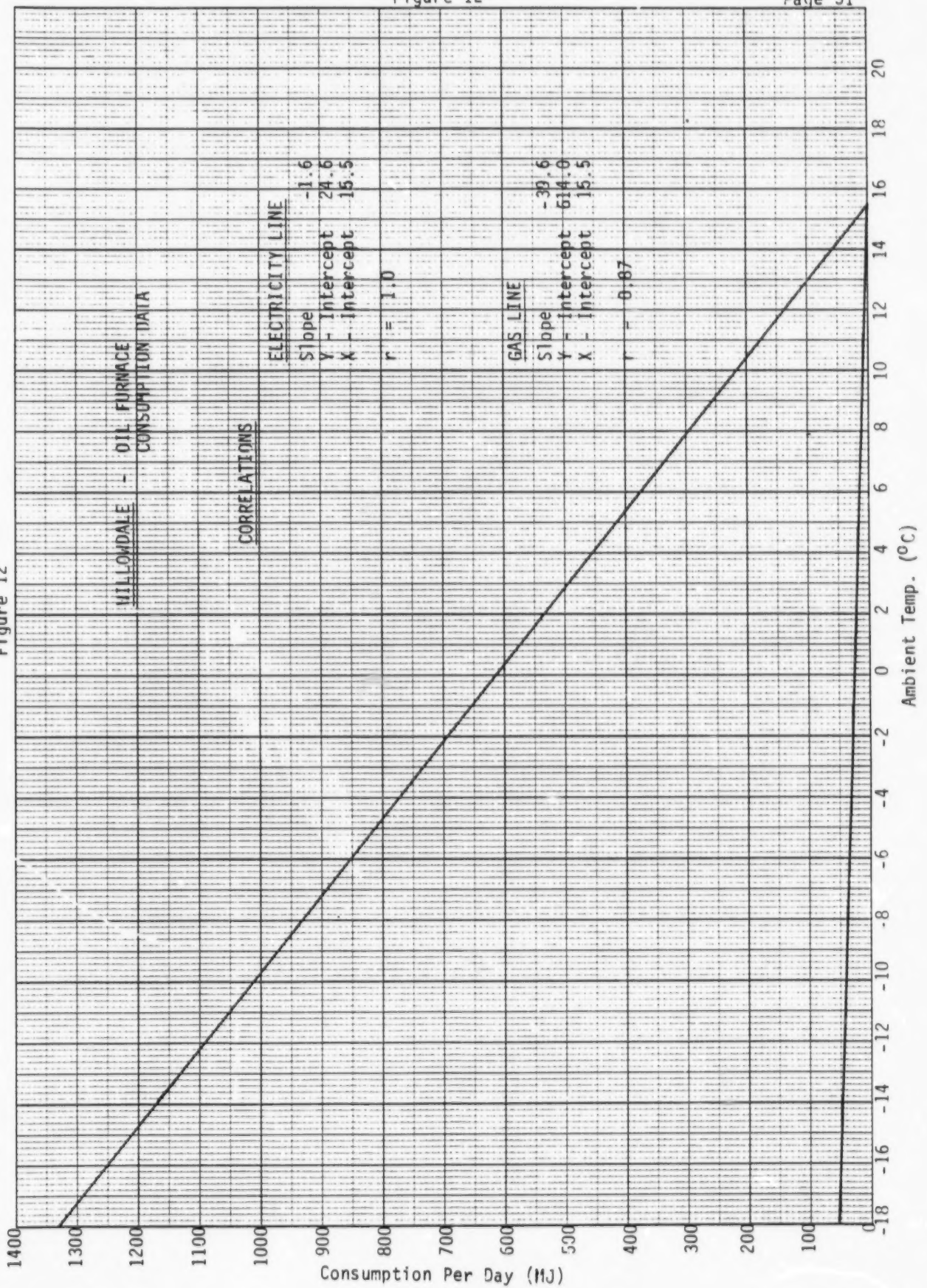


TABLE VI
 SUMMARY OF OPERATING COSTS OVER PERIOD DURING THE MONTH WHICH EACH APPLIANCE OPERATED
 WILLOWDALE SITE 1981-82

MONTH	NEW SYSTEM			CONVENTIONAL UNIT		
	Elec. (\$)	Gas (\$)	Sub Total (\$)	Elec (\$)	Oil (\$)	Sub Total (\$)
December	21.90	32.76	54.66	0.99	76.47	77.46
January	37.56	57.12	94.68	1.14	79.99	81.13
February	15.16	20.79	35.95	1.46	102.84	104.30
March	21.26	32.13	53.39	0.89	63.29	64.18
April	15.73	22.05	37.78	0.32	23.44	23.76
Total			276.46			350.83

* These costs have been computed using the energy rates indicated below:

Natural Gas 21¢/m³ Oil 29.3¢/ Electricity 3.55¢/kWh

To obtain total monthly consumption the sub totals would be added.

TABLE VII

1981-82 COMPUTED SEASONAL HEATING COSTS
WILLOWDALE SITE

MONTH	MEAN MONTHLY TEMP. (°C)	CONSUMPTION/MONTH				COST/MONTH				SAVINGS (\$)
		NEW SYSTEM		CONVENTIONAL UNIT		NEW SYSTEM		CONVENTIONAL UNIT		
		Elec (kWh)	Gas (m³)	Elec (kWh)	Oil (l)	Elec (\$)	Gas (\$)	Elec (\$)	Oil (\$)	
July 81	21	0	0	0	0	0	0	0	0	0
August 81	20	0	0	0	0	0	0	0	0	0
September 81	14	195	43	18	46	6.92	9.03	0.64	13.48	-1.83
October 81	7	678	163	115	269	24.07	34.23	4.08	78.82	24.60
November 81	3	919	223	165	383	32.62	46.83	5.86	112.22	38.63
December 81	-3	1358	332	253	586	48.21	69.72	8.98	171.70	62.75
January 82	-10	1834	450	350	808	65.11	94.50	12.43	236.74	89.56
February 82	-7	1472	361	278	644	52.26	75.81	9.87	188.69	70.49
March 82	-2	1290	315	239	555	45.80	66.15	8.48	162.62	59.15
April 82	5	788	191	138	322	27.97	40.11	4.90	94.35	31.17
May 82	15	133	28	5	16	4.72	5.88	0.18	4.69	-5.73
June 82	16	63	11	0	0	2.24	2.31	0	0	-4.55
Sub Totals						309.92	444.57	55.42	1063.31	
Totals		8730	2117	1561	3629	754.49		1118.73		364.24

* This table was computed using the regression lines shown in Figures 12 and 13 and the normal monthly mean temperatures for the 1981-82 heating season.

Rates: Gas 21¢/m³

Oil 29.3¢/

Electricity 3.55¢/kWh

Table VIII on page 35 is an analysis conducted to arrive at a composite average cost related to weather. As previously, the 30 year true monthly mean temperature has been used to arrive at the figures. The analysis shows that the average annual cost to operate an existing oil furnace at the Willowdale site would be \$1,009.74 and to operate the new unit at the same site would cost \$679.02 to produce an average annual saving of \$330.72 or 33%.

From the analysis it appears that the cost to a homeowner to operate the hybrid device is significantly lower than to operate an equivalent oil fueled conventional forced warm air furnace. Whilst it can be argued that a proportion of the savings can be attributed to blocking the large flue opening when the oil furnace is not in use, it is evident that the hybrid system has the potential to reduce operating costs. Consistent with the data obtained from the Bowmanville site, the new unit provides the greatest savings in the warmer months, and it is expected that these could be even greater if the outdoor sensor controlling the mode operation was adjusted to the optimized setting and calibrated.

TABLE VIII
DATA COMPUTED TO ANNUALIZED AVERAGE 30 YEAR MONTHLY TEMPERATURE MEANS
WILLOWDALE SITE

MONTH	30 YEAR TRUE MEAN MONTHLY TEMP. (°C)	CONSUMPTION/MONTH				COST/MONTH				SAVINGS (\$)
		NEW SYSTEM		CONVENTIONAL UNIT		NEW SYSTEM		CONVENTIONAL UNIT		
		Elec (kWh)	Gas (m³)	Elec (kWh)	Oil (l)	Elec (\$)	Gas (\$)	Elec (\$)	Oil (\$)	
July	20.9	0	0	0	0	0	0	0	0	0
August	20.2	0	0	0	0	0	0	0	0	0
September	16.2	50	7	0	0	1.78	1.47	0	0	-3.25
October	10.3	453	107	93	165	16.08	22.47	3.30	48.35	13.10
November	3.8	867	210	150	359	30.78	44.10	5.33	105.19	35.64
December	-3.1	1365	334	248	589	48.46	70.14	8.80	172.58	62.78
January	-6.3	1582	388	310	691	56.16	81.48	11.01	202.46	75.83
February	-5.4	1374	337	252	598	48.78	70.77	8.95	175.21	64.61
March	-0.7	1202	293	217	513	42.67	61.53	7.70	150.31	53.81
April	6.6	682	164	120	273	24.21	34.44	4.26	79.99	25.60
May	12.8	283	65	31	86	10.05	13.65	1.10	25.20	2.60
June	18.3	0	0	0	0	0	0	0	0	0
Monthly Average	7.8	655	159	118	273	23.25	33.34	4.20	79.94	27.56
Year Totals		7858	1905	1421	3274	278.97 679.02	400.05	50.45 1009.74	959.29	330.72

* This table was computed using the regression lines shown in Figures 12 and 13 and the 30 year true monthly mean temperatures.

Rates: Gas 21¢/m³

Oil 29.3¢/

Electricity 3.55¢/kWh

4.0 FUNCTIONAL OPERATION AND INTERIM COMMENTS

Despite a few initial teething troubles prior to commissioning, these space conditioning systems performed well at each location and in a manner which was satisfactory to the owners of the properties.

There were no extraordinary service calls except for one isolated incident at one site where the outside fan motor had to be replaced at the time when the unit was switched from winter to summer operation. This service item was covered under warranty.

It should be remembered however, with respect to service that these installations are not really representative of a typical installation, which would be purchased, installed and left alone, because under the test conditions the appliances were inspected every day. Experience with other sites which have this type of system installed should be investigated in order to obtain a statistically significant sample of service needs.

Over the period of the tests, it was apparent that the systems rarely operated in the true heat pump mode. This observation and condition may be one of the reasons that the cost savings experienced do not match the manufacturers claims. Investigation determined that the outdoor thermostat which controls the model function of the system was incorrectly set and out of calibration significantly. Next season, the unit will be calibrated and set to a temperature level consistent with greater heat pump mode operation. This action should have a beneficial effect on the operating costs as it appears that the

savings will be greatest when the unit operates as a heat pump during the shoulder months.

Overall the data shows a good trend to obtain the magnitude of the savings at these two sites.

4.1 PERFORMANCE EFFICIENCY

Performance efficiency tests were not conducted as part of these field investigations, but Ontario Hydro Research Division at Kipling Avenue conducted laboratory tests on the space heating and cooling system, and concluded that when the novel device operated as a gas furnace, steady state efficiencies ranged from 91% to 98%. When operating as a heat pump in the heating mode, the steady state co-efficient of performance averaged 2.1 at 8°C and 1.4 at -8°C. These co-efficients of performance (C.O.P.) are considerably lower than the published figures for contemporary traditional heat pumps, which have C.O.P.'s in the region of 3.0 at 8°C and 2.2 at -8°C. These tests were conducted using propane fuel and the figure may vary somewhat, through insignificantly, when natural gas is used as the operating fuel.

It should be understood that utilization efficiency is dependant not only on the basic appliance characteristics, but also the system to which it is connected.

5.0 INTERIM CONCLUSIONS

1. The units operated in a satisfactory manner and provided adequate comfort levels in each home during the period of the test.
2. This new space conditioning system, on an interim basis, does not show any significant cost savings, 7% and \$29, against a conventional gas fueled forced warm air furnace.
3. This new space conditioning system shows, on an interim basis, substantial computed savings, 32.5% and \$364, against a conventional oil fueled forced warm air furnace over the entire heating season.
4. The steady state operating efficiencies of this space conditioning system, under laboratory conditions, show relatively high operating efficiencies in the gas furnace mode and mediocre efficiencies in the heat pump mode.

6.0 RECOMMENDATIONS

The testing and data gathering will be continued for a further heating season, as follows:

- (a) The thermostat in the outside unit which controls the mode of operation, heat pump or condensing gas furnace be re-calibrated and reset to a level consistent with maximum operation as a heat pump.
- (b) At Bowmanville, a full seasons data will be collected with daily readings and daily change over.
- (c) At Willowdale, an electric furnace or duct heater will be installed in order that the seasonal efficiency of the unit can be determined. In addition, the daily change over should be automatic for a consequent increase in accuracy.

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